acquaintance between investigators pursuing related lines of research; it has made each Association better acquainted with the character and purposes of the other; it has increased mutual esteem between the men and institutions; and it strengthened both bodies in attendance and in quality and quantity of work, and has been especially beneficial in diffusing knowledge of and interest in scientific matters among the people of two countries. Some of the benefits were felt at the meetings; yet it seems fair to regard these as but the germs of greater benefits to come as the personal and collective relations begun at Detroit and Toronto mature and strengthen.

It seems specially desirable to note the international amenities characterizing the Detroit and Toronto meetings, since minor misapprehensions have come to the surface. For example, it has been alleged in the newspapers that certain members of the American Association were treated with discourtesy at the Toronto meeting. It must be evident, in view of the prevailing harmony and the unprecedented warmth of the courtesies extended by each of the Associations, that the sources of individual criticism are to be found in personal matters and not at all in general feeling. It may not be amiss to add that the Local Secretary of the British Association has explained, through the public press, that certain Americans, who complained, through the medium of associated press despatches, of discourtesy at Toronto, were not registered as members of the British Association, and therefore occupied the precise footing of the general public, which, in the British Association, is not entitled to admission to the meetings or other participation in the work of the body. The great and significant fact is that the relations between the two Associations at Detroit and Toronto were most cordial, sympathetic and beneficial; this fact assuredly overshadows any and all petty misapprehensions, and must serve to render the meetings memorable.

W J McGee.

THE SPREAD OF LAND SPECIES BY THE AGENCY OF MAN; WITH ESPECIAL REFERENCE TO INSECTS.

Among the many influences which during the last century or two have been affecting that unstable condition of life which is expressed in the words 'the geographical distribution of animals and plants' none has approached in potency the agency of man exerted both purposely and unwittingly or accidentally.

Natural spread was for centuries the rule. Species dispersed under natural conditions along the line of least resistance. Winged animals and seeds were spread by flight and by the agency of winds, and at their stopping places thrived or did not thrive according as conditions were suitable or not suitable. Aquatic animals and plants and small land animals and plants were distributed by the action of rivers and streams and by the ocean itself. Wonderful migrations have occurred, commonly with birds, more rarely with other animials; ice floes and driftwood have carried animals and plants far from their original habitats and even volcanic action has taken part in the dispersal of species. Smaller animals, especially mollusks and insects, and the seeds of plants have been carried many hundreds of miles by birds and lesser distances by mammals.

With the improvement of commercial intercourse between nations by land and by sea another factor became more and more prominent, until in the present period of the world's history the agency of man in the spread of species, taking all plant and animal life into consideration, has become the predominating one. Potentially cosmopolitan forms, possibly even insular in-

digenes, have by this important agency become dispersed over nearly all of the civilized parts of the globe, while thousands of other species have been carried thousands of miles from their native homes, and have established themselves and flourished, often with a new vigor, in a new soil and with a novel environment.

It is obvious that this agency is readily separable into two divisions: *a*, intentional; *b*, accidental.

a. Intentional Importations. Since early times strange plants and animals have been carried home by travelers. Conquering armies have brought back with the spoils of conquest new and interesting creatures and useful and strange plants. With the discovery of America and with the era of circumnavigation of the globe such introductions into Europe of curious and useful species, plants in particular, increased many fold, while with the colonization of America and other new regions by Europeans there were many intentional return introductions of Old World species conducive to the welfare or pleasure of the colonists. Activity in this direction has been increasing and increasing. Public botanical gardens and many wealthy individuals in all quarters of the globe have hardly left a stone unturned in their efforts to introduce and acclimatize new plants, particularly those of economic importance and æsthetic quality, not failing occasionally, it must parenthetically be said, to establish some noxious weed, or some especially injurious insect; while it is safe to say that probably the majority of the desirable plants of Europe which will grow in the United States have already been introduced, and that there has been an almost corresponding degree of activity in the introduction of desirable plants from the United States into Europe. In all this host of valuable introductions there have been comparatively few which have turned out badly, aside from failures of establishment. The wild garlic (*Allium vineale*), that ubiquitous plant which gives its taste to milk, butter, and even to beef during the spring and summer months in many of our States, is said to have been intentionally introduced by the early residents of Germantown, Pennsylvania. The water hyacinth (*Piaropus crassipes*), originally grown for ornament in a pond near Palatka, Florida, escaped into the Saint John's river about 1890, and has multiplied to such an extent as to seriously retard navigation and to necessitate government investigation. The distribution of the orange hawk-weed (*Hieracium aurantiacum*), a dangerous species which has ruined hundreds of acres of pasture land in New York of recent years, was originally aided by a florist as a hardy ornamental plant. The European woad-waxen (*Genista tinctorium*) was early introduced at Salem, Mass., in fact about thirty years after the settlement of the colony. It has apparently not been used as a dye plant, but for garden and ornamental purposes only. During the last few years it has become a noxious weed throughout Essex and the adjoining counties. Standing on a rock at Swampscott on July 9th, last, the writer was able to see that the country for miles around was colored a bright yellow with enormous masses of this plant. Similar instances are fortunately rare and the majority of our noxious weeds have been accidental introductions.

Intentional introductions of animals, however, have by no means resulted as advantageously as intentional introductions of plants, with the exception of the truly domesticated species, such as the horse, ass, cow, sheep, pig, dog, cat, poultry, honey bee and silk worm of commerce. Even with such species, the grazing ranges of Australia have been overrun by wild horses to such an extent that paid hunters shoot them at a small sum per head, and the European rabbit has become a much worse plague on the same island continent.

Intentional introductions of wild species, however, have almost without exception resulted disastrously.

At various intervals between 1850 and 1867 a few pairs of English sparrows were introduced into our northeastern States to destroy canker worms, and to-day this species is an ubiquitous and unmitigated pest throughout all the austral and transition regions of North America, finding its limit only at the borders of the boreal zone, while the place of the injurious insect it was imported to destroy has been taken by another and worse insect pest which it will not touch.

In 1872 Mr. W. Bancroft Espeut imported four pairs of the Indian mongoos from Calcutta into Jamaica for the purpose of destroying the 'cane-piece rat.' Ten years later it was estimated that the saving to the colony through the work of this animal amounted to £100,000 annually. Then came a sudden change in the aspect of affairs. It was found that the mongoos destroyed all ground-nesting birds, and that the poultry as well as the insectivorous reptiles and batrachians of the island were being exterminated by it. Injurious insects increased in consequence a thousand fold; the temporary benefits of the introduction were speedily wiped away, and the mongoos became a pest. Domestic animals, including young pigs, kids, lambs, newly-dropped calves, puppies and kittens were destroyed by it, while it also ate ripe bananas, pine apples, young corn, avocado pears, sweet potatoes, cocoas, yams, peas, sugar cane, meat and salt provisions and fish. Now, we are told, nature has made another effort to restore the balance. With the increase of insects due to the destruction by the mongooses of their destroyers has come an increase of ticks which are destroying the mongoos and all Jamaicans rejoice.

The flying foxes of Australia (*Pteropus* sp.) are animals which are very destructive to fruit in their native home. Frequently some well-meaning but misguided person will arrive on a steamer at San Francisco with one or more of those creatures as pets. While it is not probable that any of the flying foxes will thrive in northern California or in fact in Austral regions, the experience is too dangerous a one to try, and the quarantine officer of the California State Board of Horticulture has always destroyed such assisted immigrants without mercy.

Less than thirty years ago (in 1868 or 1869) Professor Trouvelot imported the eggs of the gypsy moth (*Porthetria dispar*) into Massachusetts. The insect escaped from confinement, increased in numbers, slowly at first, more rapidly afterwards, until in 1889 it attracted more than local attention, with the result that in 1890 the State began remedial work. This work has steadily progressed since that time and the State has already expended something over a half million of dollars in the effort to exterminate the insect, and it is estimated that one million five hundred and seventy-five thousand dollars more must be used before extermination can be effected.

Contrast with this a single intentional importation which has had beneficial results. The Australian ladybird (*Vedalia cardinalis*) was introduced into California in 1889 with the result of saving the whole citrus growing industry of the State from approaching extinction through the ravages of the cottony-cushion scale (*Icerya purchasi*). Later importations of the same insect into South Africa and Egypt also resulted beneficially.

We have thus had sufficient experience with intentional importations to enable us to conclude that while they may often be beneficial in a high degree they form a very dangerous class of experiments and should never be undertaken without the fullest understanding of the life history and

habits of the species. Even then there may be danger, as with a new environment habits frequently change in a marked degree.

b. Accidental introductions. The agency of man, however, has been more potent in extending the range of species and in changing the character of the faunas and floras of the regions which he inhabits by means of accidental importations.

The era of accidental importations began with the beginning of commerce and has grown with the growth of commerce. The vast extensions of international trade of recent years, every improvement in rapidity of travel and in safety of carriage of goods of all kinds, have increased the opportunities of accidental introductions, until at the present time there is hardly a civilized country which has not, firmly established and flourishing within its territory, hundreds of species of animals and plants of foreign origin, the time and means of introduction of many of which cannot be exactly traced, while of others even the original home cannot be ascertained, so widespread has their distribution become.

These accidental importations would at first glance seem to have been more abundant with plants than with animals, since the opportunities for the carriage of seed, especially flying or burr-like seed, and especially when we consider the vitality of this form of the plant organism, are plainly manifold, but I shall later show that possibly even this obvious generalization must be modified in view of the multitudinous chances for free travel which the smaller insects have under our modern systems of transportation.

The agencies which have mainly been instrumental in the accidental distribution of plants are:

1. Wind storms. It is obvious that light flying seeds may be carried many hundreds of miles by hurricanes and may fall in new regions.

2. Water. This is a very important agency in the distribution of plants upon the same continent, but less important as affecting intracontinental distribution. Still they may be carried by this means from one island to another adjoining island, and when lodged in the crevices of the driftwood they undoubtedly travel greater distances.

3. Birds. Seeds are frequently carried great distances by birds. Many of the larger seeds will germinate after passing through the alimentary canal of a bird, and may thus be eaten at one point and voided with the excrement at a widely distant point. It has been shown, for example, that the local distribution of *Rhus toxicodendron* is greatly affected by the carriage and distribution of the seed in this way by the common crow. Smaller seeds are carried in earth on the feet of birds. Darwin's example of a wounded red-legged partridge which had adhering to its leg a ball of earth weighing $6\frac{1}{2}$ ounces, from which he raised 32 plants of about five distinct species, is an evidence of the possibilities of this agency, while his experiment with $6\frac{3}{4}$ ounces of mud from the edge of a pond which produced 537 distinct plants, an average of a seed for every 6 grains of mud, is still more conclusive.

4. Ballast. This is the first of the distribution methods which may be combined under the head of 'agency of man.' The discharge of earth ballast by vessels coming from abroad has been a notable means of distribution of plants by seed. We have just seen how many seeds may germinate from a very small lump of earth, and the possibilities in this direction of the many thousands of pounds of discharged ballast are very great. In fact the ballast grounds in the neighborhood of great cities are invariably favorite botanical collecting spots; they have usually a distinctive flora of their own, and from these centers many introduced plants spread into the surrounding country.

5. Impure seed. The great industry in the sale of seed which has grown up of late years is responsible for the spread of many plant species, principally, it must be said, undesirable species. Mr. L. H. Dewey says: "It may be safely asserted that more of our foreign weeds have come to us through impure field and garden seeds than by all other means combined."

6. The packing material of merchandise. The hay or straw used in packing crockery, glassware or other fragile merchandise is a frequent carrier of foreign seeds. Such goods frequently reach the retailer without repacking, and the hay or straw is thrown out upon the fields or used as bedding for domestic animals and carried out with the manure.

7. Nursery stock. Plants are often accidentally introduced by means of seeds, bulbs and root stocks attached to nursery stock or among the pellets of earth about the roots of nursery stock. The extraordinary development, of late years, of commerce in nursery stock has undoubtedly been responsible for the intracontinental carriage of many species of plants in this way.

Instances of the accidental spread of larger animals by man's agency are necessarily wanting. Of the smaller mammals the house rat and the house mouse have been accidentally carried in vessels to all parts of the world and have escaped and established themselves, the former practically everywhere except in boreal regions, or only in its southern borders, and the latter even as far north as the Pribyloff Islands, as I am informed by Dr. Merriam. Small reptiles and batrachians are often accidentally carried by commerce from one country to another, but although there are probably instances of establishment of such species none are known to me at the time of writing.

Land shells are often transported accidentally across the ocean in any one of the many ways in which the accidental transportation of plants and insects may be brought about, and by virtue of their remarkable power of lying dormant for many months are able to survive the longest journeys. The conditions which govern the establishment of species in this group, however, seem somewhat restrictive, whence it follows that comparatively few forms have become widespread through man's agency, although Binney mentions a number of European species which have been brought by commerce into the United States and have established themselves here, mainly in the vicinity of the seaport towns of the Atlantic coast.

With the earthworms a striking situation exists. It has been shown that, "without a single exception, the Lumbricidæ from extra-European regions are identical with those of Europe; there is not a variety known which is characteristic of a foreign country."* Careful consideration of the evidence seems to show that this is due to accidental transportation by the agency of man.

Comparatively little has been done in the study of the geographical distribution of insects. In the words of Wallace:

"The families and genera of insects are so immensely numerous, probably exceeding fiftyfold those of all other land animals, that for this cause alone it would be impossible to enter fully into their distribution. It is also quite unnecessary, because many of the groups are so liable to be transported by accidental causes that they afford no useful information for our subject, while others are so obscure and uninteresting that they have been very partially collected and studied, and are for this reason equally ineligible."

Nevertheless, the time has already arrived with some groups, and is not far distant

*F. E. Beddard, Text Book of Zoogeography, Cambridge, 1895, p. 153.

even with the others which Mr. Wallace has termed 'obscure and uninteresting,' when, owing to the indefatigable industry of entomologists as a class, important facts can be gained along distribution lines from the group of insects. Thus it is only within the past few months that the publication of Mr. W. F. Kirby's 'Catalogue of the Odonata of the World' has made it possible for Mr. G. H. Carpenter, of the Royal Dublin Society, to prepare a comprehensive paper on the geographical distribution of the dragon-flies, a group in which a comparatively few workers have interested themselves. It is in a measure true to-day, as it was entirely true when Wallace wrote, that "many of the groups are so liable to be transported by accidental causes that they afford no useful information for our subject," yet even with the group in which the greatest obscurity as to the original home of the species has existed, owing to a very easy and most frequent commercial transportation—the Coccidæ or scale-insects—the continued discovery and characterization of new forms from all parts of the world, and especially of those existing in wild regions, away from the influence of man, are gradually giving us an insight into the probable character of the original coccid faunas of more or less restricted regions.

By reason of the drawbacks mentioned, Wallace considered only "a few of the largest and most conspicuous families which have been so assiduously collected in every part of the globe and so carefully studied at home as to afford valuable materials for comparison with the vertebrate groups." These groups included 16 families of diurnal Lepidoptera and six of the families of Coleoptera. Even with this restriction among the beetles, however, he must have had some difficulties with the accidental importations, for among the beetles are hundreds of examples of this class of introductions. For example, writing later in his Island Life, the great naturalist shows that in 1880 the total number of species of beetles known in the Azores amounted to 212, of which 175 were European. Out of these, however, no less than 101 were believed to have been introduced by human agency. Concerning St. Helena he quotes Mr. Wollaston's opinion that 74 of the 203 species have certainly been introduced by the agency of man.

In considering the question as to the regions with which an interchange of forms is most likely to occur, it is obvious that they are those which have the greatest similarity of climate, and, most nearly, identity in point of time of seasons, those in fact which are most likely to afford similar environmental conditions. A study of the similarity of faunas and floras already existing will lead us to the same result. Wallace has pointed out that with the Coleoptera the best marked affinities between regions are those between the Nearctic and the Palearctic, the Oriental and Australian, the Australian and the Neotropical, all of which appear to be about equal in each case. Next comes that between the Ethiopian and the Australian on the one hand and the Ethiopian and the Neotropical on the other, which also appear about equal. Then follows that between the Nearctic and Neotropical regions, and lastly, and by far the least marked, that between the north temperate and south temperate regions.

Further, in the consideration of accidental commercial importations, the amount and frequency of commercial interchange and the rapidity of the journey are most important factors.

From all of these considerations combined we arrive at the conclusion that the regions with which accidental interchange of species should be most frequent are Europe and North America, and this is with insects to a certain extent borne out

by the facts. The introduction of species from Europe into North America is of every-day occurrence and their establishment is far from rare. The carriage of American species to Europe is an equally frequent matter, but their establishment is much less frequent.

I have studied in this connection—my profession being that of an economic entomologist—principally the species which are prominent as injurious to horticulture or agriculture or in other ways inimical to man. Listing the insects of prime economic importance in the United States, the species each of which almost annually causes a loss of hundreds of thousands of dollars, we find that they number seventy-three. Of these thirty are native, while thirty-seven species have been introduced, six species being of doubtful origin. Of the thirty-seven introduced species, thirty have come to us from Europe, all, with one exception, as accidental importations.

Of the prominent European injurious insects, on the other hand, but three are said to have come from America; the grape-vine Phylloxera (*Phylloxera vastatrix*), the woolly root-louse of the apple or 'American blight' (*Schizoneura lanigera*), and the Mediterranean flour moth (*Ephestia kuhniella*). Of these but one is certainly American—the Phylloxera. The origin of the Schizoneura is somewhat doubtful, while the Mediterranean flour moth is not American, but probably came to us from Europe, although originally it is probably Oriental.

As with these insects of prime economic importance, so it is with other less noted species. There have been rather frequent establishments of European species in America, but practically none of American species in Europe. The reason for this curious condition of affairs is difficult to find. The general trend of accidental importations seems to have been westward, and it is doubtless a fact that certain of our now cosmopolitan forms were originally Asiatic and have traveled westward, through Europe, to and across America, and thence to Hawaii, New Zealand and Australia. The existence of such a law is borne out in the study of plants as well. The statement just made regarding insects of prime economic importance is almost exactly paralleled with the plants classed as weeds. It has thus been shown that, out of two hundred American weeds, one hundred and three are introduced, of which ninety-six are from Palearctic regions, sixty-eight being native to Europe, while it seems that less than half a dozen American species have become troublesome in Europe. A number of American species, however, have been carried to Australia and flourish there with vigor.

This general trend from east to west has always been in the direction of the newer civilization—from the older civilization to the newer. That this in itself is significant cannot be doubted, and in the case of the insect and plant enemies of agriculture the facts surrounding this condition are almost in themselves sufficient to account for this directive movement. I have shown in another paper that the denser population of the older countries and the resulting vastly smaller holdings in farms, the necessarily greatly diversified crops, the frequent rotations of crops, together with the clean and close cultivation necessitated by the small size of the holdings, and the cheaper and more abundant labor, will all operate as a barrier against the establishment of injurious species, while the reversed conditions in a newer country at once liberate an introduced species from the repressive conditions which affected it in its original home and encouraged its establishment, multiplication and spread. But there are deeper causes than this at work. It has been suggested that the flora and fauna of America, the older continent, have

become degenerate through age and cannot successfully resist competition with the more vigorous forms introduced from the younger continent of Europe,* and that there are not-yet-formulated climatic differences favorable to the development of Palearctic forms on the American continent; but these theories seem insusceptible of proof, and for the present we must content ourselves to accept the facts as we find them.

The insects which are accidentally imported are carried in three main ways. Either (1) they are unnoticed or ignored passengers on or in their natural food, which is itself a subject of importation, such as nursery stock, plants, fresh or dried fruit, dried food stuffs, cloths, lumber or domestic animals; or (2) their food being the packing substances used to surround merchandise or the wood from which cases are made, they are thus brought over; or (3) they may be still more accidental passengers, having entered a vessel being loaded during the summer season, and hidden themselves away in some crevice. The coleopterists (Hamilton and Fauvel) make a distinction by name among these classes, calling the first group 'insects of commerce' and the latter 'accidental importations.'

It would appear on the face that these more strictly accidental importations must be rarer than those which are termed commercial importations, yet of the 156 introduced Coleoptera recorded by Dr. Hamilton in 1889, sixty only were considered by that writer as insects of commerce, while 96 he thought had been brought over in this accidental way.

The remaining Coleoptera common to North America and the Palearctic region, 278 in all, Dr. Hamilton considers to be practically circumpolar species, or at least not imported. Fauvel in his remarks and additions to Hamilton's catalogue raises the number of non-introduced or circumpolar species to 366, leaving 125 as imported, of which only 28 appear to have been imported from temperate Europe, the rest being cosmopolites or subcosmopolites. Of the latter class he thinks that 59 originally came from the temperate Europeo-Siberian fauna, 10 from the Oriental fauna, 15 from the Ethiopian, 4 from the Neotropical, 7 being uncertain and 2 unknown.*

It should be noted, however, that there is grave room for difference of opinion regarding a number of the European species considered by him as indigenous to North America. *Scolytus rugulosus, Hylastinus trifolii, Anthrenus scrophulariæ, Sitones hispidulus, Cryptorhynchus lapathi*, and a number of others which might be specified, have undoubtedly been imported from Europe and were quite possibly originally imported.

There are obstacles in the way of the establishment and spread of species which are imported quite by accident which usually do not exist in the case of the so-called commercial importations. In many cases, entering the vessel by accident, they exist there as single individuals, and upon liberation, even should the conditions be favorable, only gravid females could perpetuate the species. Then also the majority of such specimens are liberated, upon the unloading of the vessel, upon the wharves. The water front of a seaport city is not a favorable place for the establishment of a species which feeds on living vegetation. Frequently, even when it is a species well fitted for acclimatization, it will have to fly or be carried for miles inland before it can find a place possible for the establishment of the species. So it happens that while foreign insects are frequently found in living condition about the wharves of our

* The spread of European species in Australia has been explained by the superior energy of the younger races of the Palearctic region.

* Hamilton, in his 1894 paper, raises the number of Coleoptera common to the two countries to 594, making the number of introduced species 216.

larger seaports during the summer months, almost none have succeeded in getting a foothold in the vicinity. Mr. Otto Lugger, when living in Baltimore, Md., made a collection of many species of foreign insects found upon the wharves, yet he has recorded the establishment of but a single species, viz, *Aphodius erraticus*, an European dung-beetle, which managed to get to Druid Hill Park, where it bred in the dung of the tame deer, afterwards spreading into the surrounding country and breeding in the dung of sheep and other domestic animals.

Practically, therefore, after many years of the most active commerce, the insect faunas of the immediate vicinity of the larger seaports, like New York, Boston, Philadelphia and Baltimore, have not been greatly changed by the introduction of foreign elements.

All of the household insects and true city insects are, of course, exceptions, to this conclusion and the strong flying, vigorous, and simple living dipterous insects—the very ones most likely to enter a loading vessel and to escape on the discharge of its cargo—will many of them find proper places for breeding. It is likely that a much larger proportion of the many species of Diptera common to Europe and North America have been brought over in this accidental manner than is the case with the Coleoptera.

But often these purely accidental species are carried inland in packing cases, into the cracks of which they may have crawled, or even in the trunks of passengers, and they may then be liberated in more favorable localities. For example, Mrs. H. G. Hubbard, after spending the summer on Prince Edward's Island, returned in the autumn to Detroit, Mich., and in unpacking her trunks her husband found two specimens of *Phytonomus punctatus*, a species not previously known to occur in Michigan, although found there in injurious numbers a year or so later. It is altogether likely that the imported elm leaf-beetle (*Galerucella luteola*), an insect which enters houses for hibernating purposes, was first brought to America in this manner.

It is, however, the accidental commercial importations which theoretically stand the best chance of establishing themselves, since, in the first place, they are generally imported in or upon their natural food. In the second place, they generally occur in considerable numbers, instead of as isolated individuals, as with the more purely accidental importations; and, in the third place, they are usually carried as originally packed, far from the port of entry.

With insects brought over on plants or nursery stock the conditions could not well be much more favorable. Their supply of food is looked after with care, the host plant is soon put in the ground in the best of surroundings, and the greatest care is taken of the choice importation. Upon or in importations of this kind are carried Coccidæ in all stages of growth, and often, fortunately, their enclosed parasites, the eggs of Aphididæ, the larvæ of wood-boring Coleoptera, the eggs of many other insects, the cocoons of small Lepidoptera, and probably even in rare cases the larvæ of Lepidoptera, since it now seems likely that *Euproctis chrysorrhœa* was imported into Massachusetts on nursery stock in its larval hibernacula. The Coccidæ, however, are most abundantly carried in this way. Under natural conditions these insects have usually a rather restricted distribution, but by means of this commercial distribution many of them have become of almost world-wide range, and the end will certainly not be reached until every country possesses every species of scale insect which can possibly live in its climate. A few instances drawn from a recent paper by Mr. Cockerell will illustrate this fact:

Diaspis amygdali, or *lanatus*, was described from Australia in 1889. To-day we know it

from Australia, Ceylon, Hong Kong, Japan, several localities in the United States, Jamaica, San Domingo, Grand Cayman, Barbadoes, Martinique, Trinidad and Cape Colony.

Aulacaspis rosæ was described from Europe, but is now found also in the United States, Australia, New Zealand, the Sandwich Islands, China and Jamaica.

Chionaspis citri was described from Louisiana and Cuba in 1883 and is now known from Trinidad, Antigua, Demarara, Bermuda, Mexico, Tonga, New Zealand and Australia.

Howardia biclavis was described in 1883 from specimens on hothouse plants in Washington, D. C. Now it is known out-of-doors from Trinidad, Mexico, Tahiti, Sandwich Islands and Ceylon.

Lecanium oleæ is found in Europe, the United States, the West Indies, Mexico, Sandwich Islands, New Zealand, Australia and Cape Colony.

The hymenopterous parasites of the Coccidæ, by virtue of their mode of life, have spread almost equally with their hosts by means of this commercial transportation. I have been able to show recently that by this means a number of species of the Chalcidid subfamilies Aphelininæ and Encyrtinæ have, in comparatively recent years, become cosmopolites. For example:

Aspidiotiphagus citrinus, originally described from California in 1891, is now found in many other portions of the United States, in the West Indies, Italy, Austria Ceylon, China, Formosa, Japan, Cape Colony, Queensland, South Australia and Hawaii. Practically the same remarkable distribution is followed by *Prospalta aurantii*, *Aphelinus mytilaspidis*, *A. diaspidis* and *A. fuscipennis*, while the remarkable and system-breaking Encyrtine—*Arrhenophagus chionaspidis*, described by Aurivillius from Swedish specimens in 1888, has since been found in Austria, Italy, several portions of the United States, Ceylon, Japan, Formosa and China.

Only second to the Coccidæ in the facility with which they are transported in this way are the Aphididæ. These insects, however, are fragile, soft-bodied and unprotected. They are readily carried, however, in the winter-egg condition and many species are rapidly becoming cosmopolitan. They have not been studied, however, elsewhere than in Europe and the United States, and the extent to which this commercial distribution has been carried can only be surmised. A suggestion of this extent, however, occurred to me when within the past few weeks specimens of *Aphelinus mali*, a common parasite of Aphididæ in Europe and North America, were received from such a comparatively out-of-the-way corner of the world as Passarœan, Java.

Other still smaller and still less studied insects are undoubtedly carried by this method of transportation, as the recently discovered identity of certain North American Thysanoptera with those of Sweden and Russia would seem to show. The small plant-feeding mites of the family Phytoptidæ are particularly subject to this form of commercial distribution, and when they are fully studied, it will doubtless be found that many forms have become subcosmopolitan.

Of larger insects, nearly all of the wood-boring beetles common to Europe and the United States have probably been brought over in this way. *Zeuzera pyrina*, the large wood-boring cossid moth, also probably came over on living plants; and, as I have just stated, the newly imported brown-tail moth, *Euproctis chrysorrhœa*, was probably at Boston with nursery stock.

Careful observations on the insects transported with this class of merchandise have never been made, except, possibly, at the port of San Francisco. At this port the

State Board of Horticulture has established, under State laws, a quarantine for all incoming plants and fruit. The entomologist and quarantine officer, Mr. Alexander Craw, has entire jurisdiction over such articles consigned to points within the State, and examines, destroys and fumigates at his discretion. He has not, however, in his reports, given us complete lists of the insects collected in this work, although I understand, from persons who have visited his office, that he has preserved collections of the more important species from an economic standpoint. The vessels examined have, almost without exception, come from Pacific ports, and the difficulty of naming insect material thus received would be very great. It is this fact which has probably hitherto prevented the publication of a general list. A list of the scale insects, however, has been published.*

Between July 2, 1894, and August 29, 1896, Mr. Crew inspected 232 vessels carrying plants or other articles liable to be infested with living insects, and consigned to California individuals or firms. 122 lots he found clean and passed; 40 lots he admitted after fumigation; 20 lots he destroyed and 78 lots he destroyed in part. One lot, consisting of 1,000 boxes of apples, he sent back on the refusal of the owner to allow them to be fumigated.

Living plants and nursery stock afford, then, perhaps, the most certain means for the accidental transmission and subsequent establishment of many kinds of insects. Commerce in objects of this class is rapidly increasing and has already assumed considerable proportions, the imports into the United States alone in the fiscal year ending June 30, 1896, having reached a value of nearly $1,000,000, while the previous year they amounted to something over $600,000.

* Bull. 4. Tech. Ser. Div. Entom. U. S. Dept. Agric., 1896, pp. 40–41.

No great elaboration will be needed concerning the importation of foreign insects upon fruits, fresh and dry; other dry food stuffs; cloths; lumber, or domestic animals. Fruits were imported into the United States in the fiscal year 1895–6 to the value of nearly $20,000,000, and, unquestionably, upon imported fruits are carried many insects. The opportunities for the establishment of species coming with fresh fruit, however, are obviously slight as compared with those which come on living plants or in dried food-stuffs, and, as a matter of fact, it appears that already nearly all of the dried-food insects have become cosmopolitan. The same may be said of the insects which affect domestic animals. The forms which are truly parasitic in the larval stage have most of them been carried everywhere, while the other forms which attack domestic animals only as adults have some of them been carried far and wide. As an example, we may recall the European *Hæmatobia serrata*, which was brought to New Jersey probably in 1886, and which has spread over the entire country from Maine to California.

The fact that insects may be, and doubtless are, transmitted in the material used in packing heavy or delicate merchandise must not be overlooked. We have already shown that dangerous weeds have been transmitted in this way, and when the material is hay or straw the danger of importing certain injurious insects becomes great. *Cecidomyia destructor*, the well-known Hessian fly, is supposed to have first been brought to the United States from Europe in straw bedding on troop vessels during the War of the Revolution, and to have recently been carried from Europe to New Zealand in the straw packing of merchandise. Laws recently proposed in New Zealand, Australia and Cape Colony provide that such straw or hay packing shall be burned immediately the case is opened.

Dr. H. Loew, in his well known paper, 'Ueber die Diptern-fauna des Bernsteins,' has shown that several of the species of the genera *Oscinis* and *Chlorops* have gained a wide distribution through commerce, and this probably happened through their occurrence in hay or straw used as packing, since they live in the stems of grains and grasses. Dr. Loew, by the way, considered the Diptera, by virtue of the simple conditions required for their existence, to be peculiarly susceptible to commercial and accidental distribution, and was inclined to believe that the majority of the many species common to Europe and North America have been imported into the latter country. He understood, however, the existence of a circumpolar fauna and wrote wisely and learnedly about the common ancestry of what he called analogous species. Whatever may be the cause, the Diptera seem fitted in the individual to withstand widely differing environmental conditions. The group, as a whole, has apparently little faunistic value either along broad lines or in a more restricted way. There are comparatively fewer characteristic genera in the main faunal regions of the world than in other groups of animals, and in our own country there are comparatively few species of restricted distribution. Very many individual species range through the Lower and Upper Austral, through the Transition and into the Boreal regions.

Aside from the Diptera, grains and grasses all over the world are subject to the attacks of a host of insects of all kinds, many of which hibernate on or within the stems, so that the proposed legal provisions of the English colonies mentioned are by no means unwise. The substitution of the wood material known as 'excelsior,' the use of which is becoming so common in this country, or of some other packing material, will shortly do away with a large share of this danger.

There are, of course, other less important methods by which insects may be transported, such as in earth or damp moss about the roots of plants and in sand used for ballast. These methods, however, are not very important as a rule, although it is stated that the destructive chigoe (*Sarcopsylla penetrans*) was carried in ballast in 1872, on a vessel from Rio Janeiro to the coast of Guinea, where it has established itself most perfectly, having been found 200 miles inland by Stanley.*

There remains one more source of accidental introductions and it is one which has been reasonably prolific as regards insects on several occasions. I refer to international expositions, which are now becoming of almost annual occurrence. At the Centennial Exposition at Philadelphia, in 1876, the insects occurring in the exhibits, especially of foreign grains, received some study by Dr. Riley, who published a short note in the Proceedings of the St. Louis Academy of Science for October 2, 1876. A special committee of the Philadelphia Academy, consisting of Drs. Horn, Leidy and Le Conte also prepared and published a report at this time, but none but well known and cosmopolitan forms were found. I am not familiar with the results of any studies of a similar nature made at the Paris Exposition Universelle of 1889, but have seen the title of a paper by M. Decaux which reads 'Etudes sur les insectes nuisibles receuillis à l'Exposition Universelle,' Paris, 1890, which, however, I have not been able to consult.

In 1893, however, careful observations were made at the World's Fair at Chicago by Mr. F. H. Chittenden, the results of which were published by Dr. Riley in Volume VI. of Insect Life. Insects to the number of 101 species were found in grain and other stored vegetable products. Seven species were found affecting animal products

* 'Die Umschau,' July 17, 1897, p. 523.

and 13 wood-feeding species were found in the forestry building. The interesting and significant fact is mentioned in this article that there was an exchange of seed samples between the representatives of different countries, which would, of course, greatly facilitate the spread of seed-inhabiting insects, and it was further shown that thousands of samples were taken away from open bags by visitors from all parts of this country and probably from other parts of the world. Moreover, at the close of the Exposition the sheaves of cereals used in the decorations were taken away by armfuls by visitors. After summarizing the habits and countries of origin of the different species, however, Dr. Riley expressed the opinion that no dangerous importations were made at this time. It seems altogether likely, however, that *Phyllotreta armoraciæ*, a European species which has established itself in northern Illinois, Iowa and Wisconsin since 1893, and which was found by Mr. Chittenden in that year in vacant lots near the exposition grounds, was an exposition importation. Moreover, an interesting Calandrid of the genus *Tranes*, the species of which are all Australian, has established itself injuriously in greenhouses in St. Louis as the result of the introduction of two plants of *Zamia spiralis* which were bought at the World's Fair. With these instances in mind we cannot but admit that other species heretofore overlooked probably escaped and have become acclimatized as the result of this exposition, and that such occasions, occurring as they do more and more frequently and drawing constantly increasing material from all parts of the world, will, unless precautionary measures are instituted, afford more and more frequent opportunities of a very favorable kind for the spread of injurious species.*

We have thus seen how great the opportunities are under our modern conditions for the transportation, in proper condition for establishment, of insects of many groups, and from this point of view it seems strange, in view of the very numerous importations, that more species do not become acclimatized even in North America, where, perhaps, we reach the greatest possibilities in this direction. Our most intimate commercial relations are with the great faunal region most like our own, and these relations are rapidly growing both with Europe on the east and with Asia on the west, although our Asiatic importations are more abundant from the Oriental region than the Palearctic, and from the Oriental we are not so likely to receive species which will acclimatize themselves. We have already pointed out that the faunistic relations with the Coleoptera (and undoubtedly with other groups) are least marked between the north temperature and south temperate regions, and this distinction is never likely to be disturbed by imported species on account of the diametrically opposed seasons. A species starting from Argentina in the height of summer will reach the United States in the dead of winter at a time least likely to favor its acclimatization. This point was first suggested by my colleague, Mr. E. A. Schwarz, in his paper entitled 'The Coleoptera common to North America and other Countries' (Proc. Entom. Soc. Wash. I., 182–194).

It appears from what we have shown that very many species are constantly being imported which do not become acclimatized. Many of the European species which we should most expect to take hold in this country have not done so, while

* During the later months of the World's Fair precautionary measures were instituted under Mr. Chittenden's supervision. Much dry food material was fumigated with bisulphide of carbon, and many samples which were very badly infected were burned. At least four new and dangerous species of insects were destroyed in this way.

with others it is the unexpected which has happened. As Osten Sacken says, speaking of the Diptera: "Importation will not occur for centuries in cases where it might be expected from day to day; and, again, it will sometimes take place under circumstances most improbable, and, *a priori* impossible to foresee." (Proc. Entom. Soc. Lond., 1894, p. 489.)

Why should the well-known *Pieris rapæ* have made its appearance in this country and spread far and wide, while the equally common and injurious *Pieris brassicæ* and *P. napi* have never been found here? Why should *Phytonomus punctatus* have flourished with us when it is hardly known as a clover enemy in Europe, and when the congeneric *Phytonomus meles* of Europe has never been found here? Why should *Coleophora laricella* have established itself here, and none of the other European Coleophoras (some of them of much greater distribution and hibernating in cases of protective coloration and shape, and attached to plants) have acclimated themselves amongst us? Why should *Calliphora vomitoria*, *Crytoneura stabulans* and *Stomoxys calcitrans* have been brought over at an early date and flourished to excess in America and many other countries, while *Sarcophaga carnaria* is unknown in any of them?

Mr. Schwarz has phrased it: "We stand here before some great unknown factor, viz, the individual character and inmost nature of the species which governs the introduction or non-introduction of each species—a factor which is variable according to each species * * *." But there is is no reason why a mystery need be made of this condition. In a word, it is the capacity of the individual species to accommodate itself to a more or less novel environment. Nowhere in the whole animal kingdom do we find the natural environment more complicated than with insects. Conditions are frequently dependent upon conditions in an almost endless chain. The phenomena of fatal parasitism are of vital importance as determining the abundance of the species and are curiously complicated. I have recently proved the existence of several fatal tertiary parasites and the probable existence of quaternary parasites with *Orgyia leucostigma* in Washington. Upon the condition of this chain of interdependencies rests the welfare of the primary host. If adverse conditions affect the quaternary parasite, the primary host suffers, for the tertiary parasites increase and kill off the secondary parasites, allowing an increase of the primary parasites which kill off the Orgyia. The famous instance of Darwin in which he showed that in a measure cats are responsible for the production of clover seed in England through the interrelations of cats, field mice and bumble-bees, is paralleled and outdone again and again among insects. Further, in no group of animals are the characteristics termed special protective resemblance and special aggressive resemblance, to say nothing of protective and aggressive mimicry, so well marked and so important in the life of the species as with the insects. *It is upon the degree of simplicity of its life—the degree of simplicity of its normal environment as a whole—that the capacity of a species for transportation and acclimatization, even into a parallel life zone, depends.*

Nevertheless, I am fully convinced that very many more species will stand transportation from the Palearctic to the Nearctic, from the Australian to the Oriental and the Neotropical regions, than would be supposed from a consideration of these points and from a knowledge of the comparatively few forms which have as yet been transported and acclimatized. Aside from the forms brought in with their food and thus under the most favorable conditions for establishment, it is only by a lucky chance with the average accidental

insect immigrant that it finds conditions for reproduction—a chance which may not occur once in very many times. Osten Sacken has pointed out that *Eristalis tenax* must have been brought here many times during four hundred years before it succeeded in establishing itself. Undoubtedly many of these immigrants die upon our wharves when a lucky chance like crawling upon the clothes of a person and thus being carried out into the country might have resulted in the establishment of the species. Given the *most favorable conditions* and many species will be able not only to accommodate themselves to a new environment, but certain of them will thrive better in the new than in the old. The effort to transport beneficial species from the Australian region and acclimatize them in the Nearctic region seemed a rash and unprofitable experiment on its face, and I confess that I for one had little hope of its success, yet it was successful with several species and transcendently successful with one.

Much has been written of late about the success of the work in the introduction of beneficial insects by Mr. Albert Koebele into Hawaii, under the auspices of the Hawaiian government. Some of the introductions seem, without doubt, to have been strikingly successful. Mr. R. E. C. Perkins has reported at some length upon this success and, in commenting upon its reasons, says:

"It becomes natural to ask why the success of the imported beneficial insects has been so pronounced here, while in other countries it has been attained in a comparatively small measure. The reason, I think, is sufficiently obvious. The same causes which have led to the rapid spread and excessive multiplication of injurious introductions have operated equally on the beneficial ones that prey upon them. The remote position of the islands, and the consequently limited fauna, giving free scope for increase to new arrivals, the general absence of creatures injurious to the introduced beneficial species, and the equability of the climate, allowing of almost continual breeding, may well afford results which could hardly be attained elsewhere on the globe. The keen struggle for existence of continental lands is comparatively non-existent, and, so far as it exists, is rather brought about by the introduced fauna than by the native one."

Mr. Perkins' reasons are all good, but he has not mentioned one prime reason of success, and that is that the most successful of the imported species have come from another portion of the same great faunal region, while others have been received from the region most closely allied, viz, the Oriental.

Wallace took the view that the effectual migration of insects is, perhaps, more than with any other class of animals, limited by organic and physical conditions. "The vegetation," he says, "the soil, the temperature, and the supply of moisture, must all be suited to their habits and economy; while they require an immunity from enemies of various kinds, which immigrants to a new country seldom obtain."

There is much truth in this statement, but it must be remarked that, in practical experience, immunity from enemies of various kinds is what insect immigrants find, not what they leave behind them. It takes some time before they weave a new chain of organism preying upon organism. Our insect importations from abroad when they are of economic importance, and those from Europe are very likely to be of such importance, leave their old insect enemies behind them and frequently are not readily attacked by native ones. These last accommodate themselves to the new comer in time, but for a while he enjoys comparative immunity. The rapid multiplication and spread of *Pieris rapæ*, of *Hæmatobia serrata*

of *Phytonomus punctatus*, of *Porthetria dispar*, of *Anthonomus grandis*, of *Icerya purchasi* and many others may probably be principally laid to this cause.

I should be remiss did I not refer to another aspect of the accidental introduction of species, viz, that it not only adds species to a native fauna, but also that it often causes the disappearance of native forms. Since the establishment, within our boundaries, of *Pieris rapæ*, our native *Pontia oleracea* has almost entirely disappeared in localities in which it formerly abounded, and in some sections has entirely disappeared. Since *Doryphora 10-lineata* came east and multiplied upon the cultivated potato in such prodigions numbers, the formerly common eastern *Doryphora juncta* has become a rare species. Walsh pointed out 30 years ago that one effect of the westward spread of the European *Mytilaspis pomorum* was to cause the gradual local disappearance of the native *Chionaspis furfurus*. Hubbard has shown that the increase of the imported *Mytilaspis citricola* in Florida was followed by the decrease of *Mytilaspis gloverii*, which, though not native, was an earlier importation—a most interesting, and, so far as records go, unique case. Instances might be multiplied which will show that the establishment of foreign species thus often produces at least a dual effect on the character of the fauna as a whole.

In closing, it will not be inappropriate to point out that the accidental importation of species is only one of the ways in which the agency of man is altering the character of native faunas, and that, in spite of its extent, it is really the least of the ways. The influence of civilization is immediately destructive to natural floras and faunas. It is already too late to gain an adequate idea of natural conditions in even recently settled portions of the globe. Wallace has dwelt upon the comparatively scanty and unimportant results to natural history of most of the great scientific voyages of the various civilized governments during the present century, from which it has resulted "that the productions of some of the most frequently visited and most interesting islands on the globe are still very imperfectly known, while their native plants and animals are being yearly exterminated. * * * Such are the Sandwich Islands, Tahiti, the Marquesas, the Phillippine Islands and a host of smaller ones; while Bourbon and Mauritius, St. Helena and several others have only been adequately explored after an important portion of their productions has been destroyed by cultivation or the reckless introduction of goats and pigs." ('Island Life,' p. 7.)

Elsewhere he shows that the introduction of goats into St. Helena utterly destroyed a whole flora of forest trees, and with them all the insects, mollusca, and perhaps birds dependent upon them. And further, that "cattle will, in many districts, wholly prevent the growth of trees; and with the trees the numerous insects dependent on those trees, and the birds which feed upon the insects, must disappear as well as the small mammalia which feed on the fruits, seeds, leaves or roots." Many local American instances have been brought together by Mr. F. M. Webster in an important paper entitled 'Biological effects of civilization on the insect fauna of Ohio,' which comes to me as I write these closing lines.

But the purpose of this address has been to dwell solely upon the question of the spread of species, and I must not touch upon other topics, however closely akin. It seems to me that the practical point to which we must come, after summarizing all that has been shown, is that since so many species have been imported by pure accident, and have succeeded perfectly in becoming acclimatized, may not much be accomplished by wisely planned and carefully guarded

introductions? The somewhat haphazard but none the less important and skillful work of Albert Koebele, first for the United States government, afterwards for the State of California, and now for the Hawaiian government, is certainly an indication, taken in connection with what we have shown, that thorough experimental work with predaceous and parasitic insects promises, in especial cases, results of possibly very great value.

We wish no more destructive birds like the English Sparrow; we have no desire to make an American resident of the Indian Mongoos, nor have we any desire to import the Australian flying fox as a pet. Neither do we desire to allow any more European plants to escape from cultivation and emulate the Russian Thistle. But there are many absolutely beneficial insects of Palearctic regions which might flourish amongst us, and whose intentional introduction could not be harmful from any point of view, while they might be of the greatest service.

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Washington, D. C.

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*PHYLOGENY AND TAXONOMY OF THE ANGIOSPERMS.**

It is unnecessary for me to state at the outset, what is evident to every botanist, that it is as yet impossible to present a complete phylogeny of the angiosperms. Phytopaleontology is too young a science, and the materials with which it deals are as yet far too scanty to have given us direct evidence as to the phylogeny of all families of plants. No one can trace with great certainty from the fossil remains of plants yet discovered the genealogy of any considerable portion of the vegetable kingdom. It will be many a year before the direct evidence we so much desire will leave no considerable gaps to be filled by skillful interpolation. However, after making all due allowance for the imperfection of the record, there are many facts as to past vegetation which are well established. Thus we know that the earliest plants were simple, homogeneous-celled, aquatic organisms. We know that ferns and gymnosperms preceded angiosperms. We know that the angiosperms which first appeared were of lower types, and that the highest types known to-day were wanting until very late in geological time.

It is true, moreover, that we are not confined to the direct evidence furnished by the paleontological record. In the individual development of every plant (its ontogenesis) there is a recapitulation of its ancestral development (phylogenesis). A critical study of the development of the individual must throw light upon the past history of the species. When we know every step in the formation of each plant we shall be able to trace the phylogeny of every species. Here, again, we have to face the fact that our knowledge is still quite fragmentary and that on this account the results are not as definite as we could wish, and yet, when we bring together what we know of the ontogeny of plants here and there in the higher groups, we are able to make out with much certainty not a little as to their phylogeny. To the details regarding these results I will advert somewhat later.

There is still another line of inquiry open to us, namely, the morphological, in which account is taken of the varying development of homologous tissues, members and organs. Rightly interpreted, the results of morphological studies are of very high importance in determining genetic relationships. When differences in homologous parts are regarded as but the expression of variation from a common form they become indices of relationship, and when

*An abstract of the address of the retiring president, delivered before the Botanical Society of America, Toronto meeting, August 17, 1897.